Firm Productivity and Type of Innovation: Evidence from the Community Innovation Survey 6

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CroEconSur
Vol. 16
No. 2
December 2014
pp. 121-146

Received: September 16, 2014
Accepted: October 22, 2014
Research Article

doi:10.15179/ces.16.2.5

Abstract

Having recognized the impact of innovation for the improvement of productivity in firms and for the growth of national economies, researchers have been exploring the innovation process and its underlying factors for over a decade now. Much of the empirical findings in this area have been based on national firm-level studies while research that encompasses several countries, particularly in transition economies, is still rare. This paper attempts to fill this gap by investigating the impact of innovation on firms' productivity across a number of East and West European countries, using a structural model based on Crepon, Duguet and Mairesse (1998) and a firm-level dataset from the 2006 round of the Community Innovation Survey (CIS6). In contrast to previous studies that focused only on product innovation as the measure of innovation output, we distinguish between firms engaged in only one type of innovation activities (product or process) and those engaged in both types. The results of the investigation provide support for the relationship between different stages of the innovation process and confirm the impact of innovation output on productivity. In addition, we find differences in the productivity associated with the type of innovation activities undertaken.

Keywords: innovations, productivity, CDM model, CIS6

JEL classification: D22, O31

1 Introduction

It is often stated that no dimension of firm performance reflects its competitiveness as closely as its productivity. An ample body of evidence suggests that the productivity of European firms, as well as that of their industries, is lagging behind that of their main rivals in the global market, e.g., firms from the USA or Japan. The search for ways to improve the productivity of firms has occupied both academics and policy-makers. Over the past few decades, the academics have attached great importance to innovation as the principle driving force of firms' productivity. Building on this foundation, policy-makers in EU countries have devised an array of measures intended to boost innovation activities and consequently the productivity of European firms. Similar efforts have been recognized at supra-national level where the need to foster innovation has been identified as one of the priorities of EU-wide development strategies such as the Lisbon Agenda or Horizon 2020.

Empirical literature has focused on the relationship between innovation and productivity. The general message coming from this body of knowledge is that innovation has a positive impact on the productivity of firms. However, the existing evidence also reveals a substantial degree of heterogeneity in firm behavior across firms and across countries. To some extent, this can be attributed to the range of measures used to portray innovation, from expenditure on R&D

to patent counts and measures of innovation output, such as the proportion of revenues gained from the sales of new products. These measures, however, focus only on a single dimension of the innovation process thus failing to encompass the multitude of types of innovation that take place within firms.

Much of the recent evidence on the relationship between innovation and productivity has been produced using the CDM-model (Crepon et al., 1998). This model portrays the innovation process as consisting of several stages: it starts with the decision of the firm to innovate, then moves on to observing the decision about the amount of innovation expenditure; the impact of the innovation expenditure on innovation output and, finally, the impact of innovation output on the productivity of the firm. In modelling innovation output these studies typically rely on measures such as sales of new products. Yet, as was previously mentioned, the innovation process within a firm has more than one dimension and can manifest itself through both product and process innovations.

This paper explores the relationship between innovation and the productivity of firms in several European countries using data from the 2006 round of the Community Innovation Survey which contains information on innovation activities and a number of characteristics of all firms with 10 or more employees in the analyzed countries. The previously mentioned CDM model has been applied in modelling the innovation process thus highlighting its different stages. However, unlike previous studies that focused on product innovations - particularly revenues from new products - as the measure of innovation output, the approach adopted in this paper encompasses several types of innovations. To this end, a distinction has been made between firms engaged in only product or only process innovations, and their counterparts engaged in both types of innovation.

The paper is structured as follows. The next Section discusses theoretical predictions about the relationship between innovation and productivity, and the empirical literature is surveyed in Section three. The characteristics of the dataset, the model and variables are presented in Section four. The discussion of the results of the investigation takes place in Section five. Finally, Section six is the concluding section.

2 Theoretical Framework

The existence of heterogeneity among firms with respect to their performance (productivity), characteristics and behavior has been acknowledged by economists for decades. Traditionally, the differences among firms have been considered as a transitory phenomenon of firm behavior. Under a neoclassical framework, heterogeneity is a feature of firm behavior in the short run while in the long run all firms converge to the steady state rate of growth (Knight, 1921). More recent theoretical models, backed up by a sizeable body of empirical evidence, suggest that the superiority of some firms over others in terms of their performance is likely to be persistent over time (Kemp et al., 2003).

Among the sources of heterogeneity, much attention has been paid to the innovation activities of firms. A line of research stretching from Schumpeter (1934), to evolutionary economics (Nelson and Winter, 1982) and to the endogenous growth literature (Romer, 1990; Grossman and Helpman, 1994; Aghion and Howitt, 1998) holds that engagement in innovation acts as a source of differentiation among firms. For a limited period of time this innovation provides the firm with the benefits of monopoly thus enabling it to accrue above average returns and outperform its rivals. The benefits of innovation, however, are not reserved only for a firm. The monopolistic nature of innovations means that they eventually become diffused across the market. From there it follows that their benefits in the long run are not reserved for the original inventor or holder but for the entire industry.

While acknowledging the importance of innovation for the performance and competitiveness of firms, the identification of the drivers of innovation has been different in different schools of thought. The Schumpeterian literature describes innovation as a product of entrepreneurial desire to move boundaries and change the existing organizational structures. This desire leads to the introduction of new goods, new methods of production, new markets and sources of supply, which is a process defined by Schumpeter (1934) as 'creative destruction'. Evolutionary and resource-based literature explains innovation in the context of adjustments in firm behavior towards the requirements of its environment. In this context, innovation is identified as a precondition for the survival of firms in changing environments and is seen as a combination of change in existing routines and the introduction of new ones (Nelson and Winter, 1982; Barney, 1991). Finally, endogenous growth literature attaches importance to the process of competition (Klette and Grilliches, 2000). In this context, the growth of a firm is determined by the quality of its own products relative to that of its rivals. Quality is, in turn, determined by the innovation activities which depend on profit margins and the ability of a firm to differentiate itself from its rivals.

3 Review of Literature

The research on the relationship between innovation and firm performance has a long tradition. The earliest studies in the field have typically investigated the relationship between R&D expenditure and measures of firm performance (Griliches, 1986; Lichtenberg and Siegel, 1991; Wakelin, 1998). Most studies following such approach have reported the existence of a positive relationship between innovation and productivity. This finding seems to hold across countries and across industries, regardless of the measure of firm performance used. However, in recent years such approach has been criticized on the grounds that R&D expenditure presents a measure of innovation input, while innovations influence productivity through innovation output. It has also been pointed out that R&D figures are subject to accounting biases, that is, they can be underreported in smaller firms or in situations when the costs of such an investment are shared by a firm and its associates such as universities, other firms or professional agencies. Finally it has been noted that not all investments in R&D transform themselves into successful innovations, which means that the benefits of such expenditure may not be exploited (Bessler and Bittelmeyer, 2008).

In recent years the research on the innovation activities of firms has focused on the complexity of the innovation process. This line of research has its origin in the CDM-model developed by Crepon et al. (1998). This model typically portrays the innovation process as consisting of four stages: the decision to innovate; the decision on the amount of innovation expenditure; the relationship between innovation expenditure and innovation output; and, the impact of the innovation output on firm performance (Loof and Hesmati, 2002, 2006; Hashi and Stojcic, 2013). In this system, the first two stages of the innovation process (decision to innovate and innovation input) are estimated jointly while the second two stages are estimated as a system. The correlation between the two parts is established through the inclusion of residuals from the second stage (decision on innovation expenditure) into a third equation of the model (the innovation output equation).

The findings from existing studies reveal a number of factors that influence different stages of the innovation process. One of the most commonly included factors is firm size. As noted by Cohen and Klepper (1996) the probability of a firm undertaking innovation increases with firm size, while, within an industry, innovation efforts and firm size are positively related across all firm size groups. Same authors note that R&D expenditure increases proportionately with firm size while innovation output per unit of innovation investment decreases with firm size. The findings from existing studies differ when it comes to firm size suggesting that the relationship between firm size and different stages of the innovation process can be positive, negative or even insignificant (Loof and Hesmati, 2002, 2006; Kemp et al., 2003). An exception is the study by Hashi and Stojcic (2013) that reports findings of all four previously mentioned stylized facts introduced by Cohen and Klepper (1996).

Another group of factors influencing the innovation process are features of the socio-economic environment such as access to finance, institutional framework, industry- and country-specific factors. Among these, studies have identified access to finance and provision of public subsidies as particularly important (Kemp et al., 2003; Hashi and Stojcic, 2013). In addition to these, evidence from some studies suggests that agglomeration externalities such as cooperation with rivals, customers and research institutes have a positive impact on the innovation process (Loof et al., 2003; Kemp et al., 2003). Contrary to theoretical predictions, only a few studies have reported a positive relationship between innovation input and innovation output (Loof and Hesmati 2002; Hashi and Stojcic, 2013). Yet, the existence of a positive relationship between innovation output and productivity has been reported by the majority of studies (Bloom and Van Reenen, 2002; Bessler and Bittelmeyer, 2008). There has also been evidence of the relationship between a firm's productivity and its size as well as the quality of human capital (Loof et al., 2003).

While in many ways being informative about the innovation process, the above literature suffers from two major shortcomings. First, most of these studies focus on product innovations as a measure of innovation output. This does not encompass fully the nature of innovation output that can manifest itself as either product or process innovations. Second, it is considered that only firms that have reported the introduction of new products and/or processes can be labelled as innovators. However, as noted by several authors, all firms engage in some degree of innovation (Griffith et al., 2006; Masso and Vahter, 2007; Halpern and Murakozy, 2012). According to these sources, the intensity of innovation varies across firms. A part of their working time is always spent on thinking up new ways to improve the production process or products, yet in some instances, such efforts might be so incremental that firms decide not to report them. When identifying innovators, these models differ from other innovation literature by focusing on the question of whether the firm invested any resources in innovation instead of asking whether they introduced product or process innovations. Moreover, instead of focusing on product innovations, innovation output is modelled as consisting of both product and process innovations. This group of studies enables the inclusion of a larger number of firms into the analysis and also encompassing of different types of innovation, that is, product and process innovations. For these reasons it has been applied in this paper.

4 The Model Specification and Dataset

The analysis in this paper is based on a structural model consisting of four stages: the decision of firms to innovate; their decision about the amount of innovation expenditure; the production of innovation output; and, the impact of innovation output on productivity. The model used differs from the majority of existing CDM-type literature in two major ways. First, rather than focusing on the sales of new products or patents as measures of innovation output, this paper allows knowledge production to take two forms – product and process innovation. Second, while existing studies label a firm as an innovator if it introduces product or process innovation, the approach used here focuses on reported values of R&D investment. Hence, it is assumed that all firms invest some amount of innovation effort but not all of them report it. For this reason, reported R&D figures are employed to predict values of innovation effort for all firms.

4.1 The Dataset

The investigation in this paper is based on data from the Sixth Community Innovation Survey (CIS) conducted in the period between 2004 and 2006. The information contained in the CIS dataset includes innovation activities of firms in the European Union member states and candidate countries, as well as Norway. This dataset (with the information on all questions) is not available to public and can be accessed only at the Eurostat Safe Center in Luxembourg. The surveyed firms are distributed across all major sectors of economic activity. In total we dealt with nearly 85,000 firms from 12 countries.[1] Of these, about 27 percent (23,000) have made some kind of expenditure on innovation activities and are thus labelled as innovators.

4.2 General Specification of the Model

The first two stages of the model are estimated using the generalized Tobit technique. Supposing that g_i^* is an unobserved variable of a firm's decision to innovate and k_i^* is the unobserved level of the firm's investment in innovation, with g_i and k_i being their observable counterparts the first two stages of the model can be defined as follows:

$$g_i = \beta_0 x_i^0 + u_i^0 \tag{1}$$

$$g_i = 1, \text{ if } g_i^* > 0, \text{ otherwise } g_i = 0$$

and

$$\begin{aligned} k_i | g_i > 0 &= \beta_1 x_i^1 + u_i^1 \\ k_i = k_i &\text{ if } k_i^* > 0, \text{ otherwise } k_i = 0 \end{aligned} \tag{2}$$

in the above expression, $x_i^0, x_i^1, \beta_0, \beta_1$ are vectors of independent variables and their corresponding parameters which reflect the impact of different determinants on the firm's decision to invest in innovation and on the actual level of expenditure on innovation. The u_i^0 and u_i^1 are random error terms with zero mean, constant variances and not correlated with the explanatory variables.

The third stage of the estimation is presented by the following equations:

$$t_i^2 = a_k^2 k_i + \beta_2 x_i^2 + u_i^2 \tag{3}$$

1 These include Bulgaria and Romania, the candidate countries at the time of the survey, six new EU members (Czech Republic, Estonia, Hungary, Latvia, Lithuania and Slovak Republic), three old EU members (Greece, Spain and Portugal) and Norway (a country with institutional developments very similar to the mature EU members). Although the Survey has been conducted in all EU member states and some candidate countries, the raw data is not available for all countries.

$$t_i^3 = a_k^3 k_i + \beta_3 x_i^3 + u_i^3 \quad (4)$$

where t_i^2 and t_i^3 represent the innovation output of firm defined as product and process innovations, k_i represents estimates of innovation output from Equation (2) and a_k^2 and a_k^3 are corresponding vectors of unknown parameters. x_i^2 and x_i^3 are vectors of explanatory variables while β_2 and β_3 are their corresponding vectors of unknown parameters. u_i^2 and u_i^3 are random error terms with mean zero and constant variance.

Finally, the fourth stage of the model is an equation that relates innovation output with the firm's performance (productivity). It can be expressed as follows:

$$q_i = \alpha t_i + \beta_4 x_i^4 + u_i^4 \quad (5)$$

In Equation (5) q_i indicates the firm's performance, t_i stands for estimates of innovation output from Equation (3) while β_4 and x_i^4 stand for parameters and vectors of other explanatory variables. As previously, u_i^4 is the random error term which is assumed to be uncorrelated with explanatory variables.

The first two stages of the model are estimated as a generalized Tobit model using the Heckman procedure in the STATA software. To this end, the existence of correlation between error terms of Equations (1) and (2) is permitted and this part of our model is similar to other CDM-studies. However, when it comes to the estimation of the third and fourth stage of analysis we rely on a slightly modified approach by Griffith et al. (2006).

The correlation between Equation (2) representing innovation input and Equations (3) and (4) representing innovation output is allowed through the inclusion of estimates of innovation output from a former Equation into the latter two Equations. As Equations (3) and (4) have categorical variables as dependent variables (explained in more detail later) they are being estimated using probit methodology. However, while existing studies estimated separate probit equations for each type of innovation, this paper considers some common factors which influence both product and process innovations of firms. For this reason, Equations (3) and (4) are estimated using a bivariate probit procedure and allowing for the existence of correlation between the error terms u_i^2 and u_i^3. Moreover, the values of innovation expenditure are being predicted from generalized Tobit Equations (1) and (2) for the sample of all firms instead of only those reporting R&D expenditure. As noted by Griffith et al. (2006) such procedure controls for the possibility of potential endogeneity of innovation input to the knowledge production function. Finally, the fourth stage of model (the productivity equation) is estimated using ordinary least squares technique (OLS) where the innovation output enters the model in form of predicted values from Equations (3) and (4).

4.3 Definition of Variables

The variables presented in the previous section are defined as follows.[2] A firm is considered as innovative if it reported a positive value for innovation expenditure. Unlike much of previous literature that defined innovation expenditure as expenditure on R&D, the definition adopted here is somewhat broader and includes expenditure on machinery, equipment, software, patents, know-how and training of staff for innovation activities. The explanatory variables of Equation (1) include the size of firm measured by the natural logarithm of employment; a dummy variable for being part of a larger group of enterprises; a dummy variable for market orientation of firm (domestic or foreign); factors hampering innovation (cost, knowledge, market and other factors); a dummy variable for firms that introduced patents over the past three years; and two dummy variables for firms that introduced organizational or marketing innovations.

Innovation input is defined as the natural logarithm of the overall amount spent on innovations in 2006. Defined this way, the variable encompasses spending on all innovation activities mentioned earlier (intramural and extramural R&D expenditure, investment in machinery, equipment and software and other

2 For a full definition of variables see Table A1 in Appendix.

acquisitions of external knowledge). As a requirement of the Heckman procedure, it is modelled as a function of all variables included in the first stage except the market and other factors hampering innovation. Hence, it is assumed that factors hampering this stage of innovation process are primarily those associated with costs and knowledge.

In measuring innovation output two variables are used. The dependent variables in Equations (3) and (4) are constructed on the basis of the firm's response to the question whether it introduced any product innovations (Equation 3) or any process innovation (Equation 4) in the three years prior to the survey. Both equations are modelled as a function of the same variables. These include: firm size; the predicted values of innovation input from Equation (2); the market orientation of a firm (domestic or foreign); experience of having previously abandoned or on-going innovations; a dummy variable for firms that applied for patents in the three years prior to survey; a dummy variable for being part of a larger group of enterprises; and, four dummy variables for factors hampering innovations (costs, knowledge, market and other).

Finally, the dependent variable of Equation (5) in the fourth stage of the model is the natural logarithm of a firm's labor productivity defined as turnover divided by the number of employees. As mentioned previously, this Equation includes the predicted values of innovation output from the previous stage. To this end, three variables are constructed on the basis of predicted probabilities from Equations (3) and (4) for firms engaging only in product or process innovations, as well as for those firms engaging in both product and process innovations. Besides these variables, Equation (5) includes firm size; a dummy variable for being part of a larger group of enterprises; organizational and marketing innovations; market orientation; previous patenting activity; and, four variables for factors hampering innovations defined previously. Finally, equations in all four stages of the innovation process contain two dummy variables for trade and service sectors.[3] In addition, a dummy variable for firms located in one of Central and East European countries (CEEC) is included.

5 Interpretation of Findings

The results of the investigation are presented in this section. As noted previously, first two stages are estimated using generalized Tobit procedure, the bivariate probit methodology is employed in the third stage of estimation while the ordinary least squares technique is applied to the fourth stage of investigation. For expositional convenience the results for each stage of innovation process will be presented in separate subsections.

5.1 The Decision to Innovate

The marginal effects of the estimation of the first stage model are presented in Table 1. As can be seen, the propensity of firms towards innovation increases with firm size and when they are part of a group of enterprises. This can be explained by larger firms more easily gaining access to the resources needed to undertake innovations, just as firms which are being a part of a group of enterprises can share knowledge, costs and other resources with other members of the group of enterprises and thus be more inclined to innovate.

The probability of engagement in innovation also increases if the firms are exporters and if they have previously applied for patents. The former finding can be related to the intensity of competition on international market requiring firms to innovate and also providing them with access to information that can be used in the development of their own innovations. The latter finding suggests that previous experience in innovation provides firms with the incentive to engage in the search for new products and processes.

3 The base group is manufacturing industry.

Table 1: *Results of the Selection Equation – Marginal Effects*

Variable	Coefficient
Firm size	0.03***
Part of group of enterprises	0.11***
Market orientation	0.12***
Patenting experience	0.24***
Organisational and marketing innovations	
Organisational innovations	0.20***
Marketing innovations	0.17***
Highly important factors hampering innovations	
Cost factors	0.10***
Knowledge factors	0.04***
Market factors	0.03**
Other factors	-0.17***
Industry specific characteristics	
Trade	-0.10***
Service	-0.01***
Institutional setting	
CEEC	-0.19***
Number of observations	84684

Note: (***), (**) and (*) indicate statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors' calculations.

Both organizational and marketing innovations have a positive impact on the decision to innovate. This can be explained by organizational innovations leading to a higher efficiency of firms and to the creativity of employees, both of which can create conditions for further innovations. On the other hand, this suggests that elements of marketing innovation such as improvements in relations with clients and suppliers or in design, positively influence the decision of firms to innovate.

A somewhat unexpected finding is the positive and significant coefficient on factors hampering innovations (with exception of variable controlling for "other" factors). This finding is similar to those reported by Loof et al. (2003) and Hashi and Stojcic (2013) according to whom factors such as knowledge and cost restrictions force firms to select from the pool of innovative ideas only those which have a high probability of success. Finally, both variables for industry-specific factors and variables controlling for location of firms in CEEC group of countries are significant with a negative sign suggesting that firms from trade and service sectors and those located in new EU member states and candidate countries are less likely to innovate.

5.2 Investment in Innovation

The marginal effects of the innovation investment equation are presented in Table 2. Overall, the findings are similar to those for the first stage of the estimation. Hence, firm size and being part of a group of enterprises, as well as having patenting experience, increase the amount of innovation expenditure invested by the firm. The same finding holds for marketing and organizational innovations.

Table 2: *Results of the Innovation Investment Equation – Marginal Effects*

Variable	**Coefficient**
Firm size	0.39***
Part of group of enterprises	1.67***
Market orientation	1.74***
Patenting experience	3.60***
Organisational and marketing innovations	
Organisational innovations	2.81***
Marketing innovations	2.38***
Highly important factors hampering innovations	
Cost factors	1.42***
Knowledge factors	0.60***
Industry specific characteristics	
Trade	-1.40***
Service	-0.14***
Institutional setting	
CEEC	-2.85***
Number of observations	84684

Note: (***), (**) and (*) indicate statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors' calculations.

Both variables for cost and knowledge factors are significant and positive. Such a finding is in line with the explanation offered in Section 5.1 and the findings of other studies mentioned there. Finally, it seems that firms from trade and service sectors invest less in innovations, just as firms from the CEEC group of countries have a lower amount of innovation expenditure compared to their rivals from the West European mature market economies. Several reasons can be associated with the latter finding. On the one hand, over the past two decades firms in these countries have built a reputation as producers of low technology intensive standardized products that do not require much innovation. On the other hand, the development of linkages between these firms and firms from mature market economies during the past two decades in the form of foreign direct investment, strategic alliances and so on provided them with the opportunity to benefit from the research activities of parent companies and associated firms. Furthermore, access to finance has been recognized as an important barrier to firms in CEEC. For this reason the financial barriers to innovation may be more important for these firms.

5.3 Innovation Output

As noted previously, in the third stage of the model, two equations are estimated using a bivariate probit technique. From this, marginal effects were calculated for the probability of firms undertaking product-only innovation, those undertaking process-only innovation and for firms undertaking both product and process innovations. The results of these estimations are presented in Table 3.

***Table 3:** Results of the Innovation Output Equations – Marginal Effects*

Variable	Product innovations	Process innovations	Product and process innovations
Innovation input	0.01***	0.02***	0.04***
Firm size	-0.01***	0.01***	0.01***
Part of group of enterprises	-0.01**	-0.01***	-0.02***
Market orientation	0.0003	-0.03***	-0.02***
Patenting experience	0.01***	-0.06***	-0.03***
Previously abandoned and ongoing innovations	0.05***	0.07***	0.27***
Highly important factors hampering innovations			
Cost factors	-0.01***	0.001	-0.02***
Knowledge factors	-0.01***	0.002	-0.01***
Market factors	0.02***	-0.03***	0.0004
Other factors	0.004	0.03***	0.03***
Industry specific characteristics			
Trade	-0.02***	0.04***	-0.001
Service	0.003*	-0.01***	-0.01***
Institutional setting			
CEEC	0.05***	-0.02***	0.05***
Number of observations	84684	84684	84684

Note: (***), (**) and (*) indicate statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors' calculations.

The first and most important point to consider is the relationship between the predicted values of innovation input from the previous stage and measures of innovation output. In all three cases, the coefficient on innovation input is highly significant and positive, providing support for the presence of a relationship between two stages of the innovation process. The evidence with respect to firm size is less conclusive. For the case of firms undertaking product-only innovations the coefficient is highly significant and negative while in the other two cases it is positive. The former result is in line with the findings from existing literature dealing with innovation output in the form of product innovations. It is also in line with stylized facts about the relationship between firm size and innovation presented by Cohen and Klepper (1996). However, findings with respect to the other two cases indicate that larger firms are more likely to engage in process innovations and to exercise combined product and process innovations.

Being part of a larger group of enterprises reduces firms' incentive to engage in either product or process innovations, while previous experience in innovation activities recognized in the literature as factor facilitating innovation throughout transformation of inputs into innovation output (Kemp et al., 2003) - has a positive effect on all three types of innovation. A somewhat unexpected finding is the negative and significant coefficient on the variable controlling for market orientation of firms suggesting that exporters are less likely to engage in process innovations and to exercise both types of innovation jointly. A similar effect is obtained in the case of previous patenting experience. However, this variable has a positive impact on the probability of firms engaging solely in product innovations.

Among the factors hampering innovation activities, variables controlling for knowledge and cost factors have a negative impact in the case of firms doing product-only innovations and those engaged in both types of innovation, while market factors enter with a positive sign for those firms engaged in product-only innovations, but have a negative impact on their counterparts doing process-only innovations. Finally, other factors have a positive impact on the engagement in process innovations and in both types of innovation jointly. While findings for knowledge and cost factors are expected, those for market factors are somewhat surprising in the case of product innovations. A likely explanation is that pressure from rivals acts as an incentive for firms to develop new products in order to survive.

Both variables controlling for industry specific characteristics and the variable controlling for institutional setting are significant. Compared to firms from the manufacturing sector, their counterparts from the trade sector are less likely to engage in product innovation, but they have a higher probability of engaging in process innovation. When it comes to the service sector, firms from this industry have a higher probability of engagement in product innovations but are less likely to develop process innovations or both types of innovation jointly than their counterparts from the manufacturing sector. Finally, firms from CEECs are more likely to engage in product innovation than their counterparts from mature market economies, but they have a lower probability of engaging in the other two types of innovation.

5.4 Productivity

The last part of the analysis investigates the relationship between innovation output and firm productivity. The results are presented in Table 4.

Table 4: *Results of the Productivity Equation*

Variable	Coefficient
Product innovations only (predicted)	-0.60***
Process innovations only (predicted)	2.27***
Product and process innovations (predicted)	0.77***
Firm size	-0.09***
Part of group of enterprises	0.69***
Market orientation	0.28***
Patenting experience	0.19***
Organizational and marketing innovations	
Organizational innovations	0.07***
Marketing innovations	-0.13***
Highly important factors hampering innovations	
Cost factors	-0.27***
Knowledge factors	-0.14***
Market factors	0.07***
Other factors	0.10***
Industry specific characteristics	
Trade	1.05***
Service	-0.10***
Institutional setting	
CEEC	-1.01***
Number of observations	84684

Note: (***), (**) and (*) indicate statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors' calculations.

As can be observed, there is a positive and statistically significant relationship between the involvement of firms in process innovations and in both types of innovations, on the one hand, and their productivity, on the other hand. However, in the case of firms doing product-only innovations, a negative and statistically significant coefficient is obtained. A similar finding was obtained by Halpern and Murakozy (2012). As noted by these authors, potential multicollinearity between the two measures of innovation may be the cause for such finding.

The coefficient on firm size is negative and highly significant. Such a finding may be taken as evidence of a quiet-life, which means that larger firms have less incentive to be efficient once they dominate a market and for this reason are likely to be less productive. Being part of a group of enterprises has a beneficial effect on the productivity of firms. Such a finding may signal that knowledge and technology transfer mechanisms within an enterprise, such as movement of workers, access to supply and distribution channels or finance, have beneficial effects on the productivity of firms. Another factor with a positive contribution to productivity is the exporter status of firms. Hence, firms that compete on international markets are more productive than their counterparts oriented only to the domestic market. Such a finding is consistent with a long line of research on the learning-by-exporting hypothesis. Accordingly, the participation of firms in international markets provides them with access to new technology, new knowledge and new product ideas which when brought to the domestic market may become their competitive advantage.

Previous patenting experience has a positive impact on the productivity of firms. Such a finding suggests that knowledge about the development of innovations gathered through previous successful innovation efforts helps firms to improve the current aspects of their behavior and thus achieve productivity gains. Organizational innovation also has a positive impact on productivity. Organizational improvements include: knowledge and quality management, business reengineering, new systems of employee responsibility, education and training systems, changes in the organization of departments, and new methods for organization of external relations. Such improvements have beneficial effects on productivity improvement channels such as: response time to customer and supplier needs; improved communication and information sharing; and cost reductions changes in the supply chain.

While organizational innovations have a positive impact on the dependent variable, the impact of marketing innovations is negative. Marketing innovations include: aesthetic changes to design or packaging of goods and services, new methods for product promotion and sales channels, as well as new methods of pricing goods and services. A likely explanation is that investment in these innovations requires certain adaptation from customers, which in the short term, may lead to reduction in the revenues of firms and exercise lower impact on productivity. Among factors hampering innovation, cost and knowledge have an expected negative sign while the sign on market factors and other factor variables is positive. As explained previously, it is likely that pressure from rivals motivates firms to improve their productivity. Similar to findings from previous stages, firms in CEEC are less productive than their counterparts in mature market economies. Finally, a positive coefficient has been found on the variable controlling for trade sector and negative one has been found for the service sector.

6 Conclusions

The importance of innovations for the performance and competitiveness of firms, industries and nations has been recognized for a long time by both academics and policy-makers. The global economic downturn and internationalization of economic activity have further strengthened the interest in innovation. The existing literature has been focused largely on product innovation and it has neglected the importance of process innovation. The objective of this paper, therefore, was to explore the relationship between innovation and productivity across a number of European countries while paying attention to three different types of innovation: product innovations, process innovations, and the engagement of firms in both product and process innovations.

The analysis provides support for the thesis that innovation is important for the productivity of firms, regardless of the type of innovation. Furthermore, the evidence suggests that larger firms are more likely to decide to innovate, spend more on innovations and have a higher probability of engaging in all types of innovation. However, these firms are less productive than their smaller rivals. As noted previously, this is likely to be the evidence of the 'quiet-life' led by these firms once they gain a large share of a market. Our findings also revealed that factors such as agglomeration externalities, learning by exporting and spillovers of knowledge within groups of firms, facilitate the innovation process, while costs and knowledge are the most important factors hampering them.

Finally, the evidence points to a gap in innovation behavior between firms from mature market economies of Western Europe and those from the new EU member states and candidate countries. The latter group of firms has a lower probability of engaging in innovation, is more likely to devote fewer resources to innovations, and is less successful in transforming innovation inputs into innovation outputs. Moreover, they are less productive than their counterparts in mature market economies. Given the importance of innovation for growth, it follows that cohesion policy and other measures intended to facilitate convergence of new EU member states and candidate countries should pay more attention to the innovation behavior of firms.

Appendix

Table A1: *Definition of Variables*

Decision to innovate	Dummy – 1 if the firm reported positive amount of innovation expenditure
Innovation input	Amount of innovation expenditure (natural logarithm)
Product innovations	Dummy – 1 if the firm introduced product innovation in three years prior to survey
Process innovations	Dummy – 1 if the firm introduced process innovation in three years prior to the survey
Productivity	Turnover per employee (natural logarithm)
Firm size	Number of employees (natural logarithm)
Part of group of enterprises	Dummy – 1 if the firm is part of a larger group of enterprises
Market orientation	Dummy – 1 if the firm is an exporter
Patenting experience	Dummy – 1 if the firm introduced patent in three years prior to the survey
Previously abandoned and ongoing innovations	Dummy – 1 if the firm had abandoned or ongoing innovations in three years prior to the survey
Organisational innovations	Dummy – 1 if the firm introduced organizational innovation in three years prior to the survey
Marketing innovations	Dummy – 1 if the firm introduced marketing innovation in three years prior to the survey
Cost factors hampering innovations	Dummy – 1 if the firm considers costs as a highly important barrier to innovation
Knowledge factors hampering innovations	Dummy – 1 if the firm considers knowledge as a highly important barrier to innovation
Market factors hampering innovations	Dummy – 1 if the firm considers market factors as a highly important barrier to innovation
Other factors hampering innovations	Dummy – 1 if the firm considers other factors as highly important barriers to innovation
Trade	Dummy – 1 if the firm belongs to the trade sector
Service	Dummy – 1 if the firm belongs to the service sector
CEEC	Dummy – 1 if the firm operates in new EU members in Central and Eastern Europe

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